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FERTILIZER DEMAND IN BANGLADESH

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ABSTRACT

This study has been performed to find out the factors affecting demand for the fertilizers, urea, triple super phosphate and muriate of potash and also to estimate the relative contribution of the factors by using econometric models. Understanding the behavior of the variables are crucial as fertilizer crisis has become a regular phenomenon and also because fertilizer is so important to our agriculture. Cobb-Douglus type production function has been conceived for the analysis and estimation was done by ordinary least square in double log form. It is found that the price of urea do not play a significant role in determining its demand but prices of TSP and MOP are vital in their demand determinanation and these demands are price elastic. Non-price factors are important as demand factors, and fertilizer demand in all the three types has seasonal variation. Considering the future direction, it is highly likely that urea has to be imported in near future at a higher international price compared to the existing domestic price.

I. INTRODUCTION

Agriculture is the dominant sector in the economy of Bangladesh. Although in recent days its contribution and proportion to Gross Domestic Product (GDP) declined but it still remains substantial and important to the economy of Bangladesh. In past few decades fertilizer has been a crucial component of agricultural sector as value added of Bangladesh Agriculture which is 'overwhelmingly' dominated by crops. Forty percent of total foodgrains is directly attributed to fertilizer use and on average eighty percent of total ferlizer sales is used for paddy. At present the major fertilizer being marketed in Bangladesh are urea (46% nitrogen), triple super phosphate (TSP) (46% phosphate/ P205), single super phosphate (SSP) (14%-18% phosphate and 10% sulphur) and muriate of potash (MOP) (60% postash/$K_2$0). In addition, some ammonium sulfate (20%-21% nitrogen), gypsum (18% sulphur) and Zine (18% sulphur and 36% Zn) are being marketed.

Urea dominates the fertilizer consumption in Bangladesh. Consumption of urea increased from 559 thousand MT in 1980-81 to 1.3 million MT in 1990-91 and to 1.7 million MT in 1994-95. Consumption of urea was 66 percent of total fertilizer sales in 1994-95 and during the same period TSP, SSP and MOP sales were 5 percent, 20 percent and 6 percent respecti

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vely of the total fertilizer consumption. Over the years TSP sale decreased and SSP sales increased substantially. Problem with fertilizer in Bangladesh has become a regular phenomenon and consequently much discussion has taken place on the availability and distribution of it. Considering the urea consumption figure and its domestic production capacity approximately at 2.2 million MT, it is apparent that there will be shortage of urea in near future if production capacity is not increased and import is absent.

Fertilizer marketing has been made open to the private sector and traders are also free to import fertilizer but production and primary distribution from the domestic factories are looked after by the government. Factors affecting demands for fertilizer are vital in formulating policy and forecasting. Most of the studies relating to fertilizer demand in Bangladesh considered fertilizer consumption in total. But the factors affecting demand for different types of fertilizer might be different. Analysis of fertilizer demand by type may help to take proper decision regarding their distribution and which may help the government to take precautionary measures for the crisis period.

The objective of this paper is to analyze factors affecting demand for urea, TSP and MOP. It was not possible to estimate the demand for SSP due to small number of observation and presence of some missing data.

Organization of this paper is as follows. Discussion on theoretical framework, variables and data are done in section II. Results are presented in Section III and analysis of the results are done in section IV and finally some concluding comments are made in section V.

II. ANALYTICAL FRAMEWORK

The Models

The demand for input by farmers is a derived demand and it is determined by the underlying demand for the agricultural commodity being produced and by the technical characteristics of the production function. In our present study we have conceived a Cobb-Douglus type production function and demand for fertilizer has been derived via the profit function (see David 1976, Parikh 1965, Subramaniyam and Nirmala, 1991 and see Timmer, 1974 for a more theoretical approach)[1].

Model 1 : Sales of each type of fertilizer is taken as the dependent variable (F). The explanatory variables are, the ratio of fertilizer price to crop price P_F/P_0, total cultivated area under HYV (HV) (In case of Boro season cultivated land under potato and wheat are also included), time variable (T) and two dummy variables (D_{Si}) for Boro and Aman season. In case of relative price, it is assumed that the impact on fertilizer demand of a one percent increase in crop price is symmetric with one percent decline in the price of fertilizer. By using this as an argument the price of fertilizer enters into the demand function relative to the price of agricultural output, that is, consumption is likely to depend on the prices paid for fertilizers relative to prices received by the farmers for the product. This relative price also eliminates the effect of inflation. The inclusion of HYV cultivated area is easily understood as chemical fertilizer is a crucial component of HYV technology. Sales of phosphate (QP_h) from other fertilizers are used as an explanatory variable in the case of TSP demand. Coefficient of all the independent variables except the relative price and sales of phosphate are assumed to be positive, the relative price and sales of phosphate are assumed to have negative signs.

Time variable is included to capture the extent of knowledge about the use of fertilizer among farmers or technological change over time and as a 'catch all variable'. The inclusion of trend variable can also avoid the problem of spurious correlation which is common in time series data (Gujarati, 1995). Dummy variables are included to consider the seasonal pattern in the data, here Aus season is taken as the comparison category. The model becomes:

$$\log F = b_0+b_1 \log (P_F/P_0)+b_2 \log HV+b_3T+b_4 D_{s1} + b_5 D_{s2} + b_6 \log QP_h+u$$

The variables are defined above, the 'b's are the parameters to be estimated and u is a stochastic variable in the model.

Model 2: This model considers the same variables as in model 1 except the fertilizer price and crop price are considered as separate arguments. The average output price has been added as an independent variable assigning a lag (P_{t-1}) to serve as a proxy for farmer's ability to finance fertilizer purchase.

$$\log F = b_0+b_1 \log P_F+b_2 \log P_{t-1}+b_3 \log HV+b_4T+b_5 D_{S1}+b_6 D_{S2+}+b_7 \log QP_h+u$$

Model 3: In the third model all the variables are same as model 1 except the relative price which is added as an argument by deflating the price of fertilizer by harvest price index, and this enters in the model as HPI[2].

$$\log F = b_0+b_1 \log HPI+b_2 \log HV+b_3\ T+b_4 D_{S1}+b_5 D_{S2+}+b_6 \log QP_h+u$$

Explanatory Variables

Some economists have argued against the use of factor price output price ratio as an explanatory variable. They fear that the assumption of symmetry might not hold true empirically in developing countries and if it is not ture, policy implications and projections might not be accurate (Timmer, 1974). The assumption which is technically known as zero homogeneity condition on the demad function, however, has its empirical validity in developed countries but it is difficult to find such studies for developing countries. We have included the ratio here because it represents profitability, besides we are unable to get any convincing empirical study on rejecting the ratio variable. In input demand it is usual practice to use these type of ratio not only in developed countries but also in developing countries and there are ample studies on this regard. This is because the ratio is a convenient way of reflecting profitability in real terms[3]. In model 2, although we have taken fertilizer and crop price separately and it is taken in nominal terms and coefficients of these two variables might not show a true picture but if one is willing to accept the assumption that over time inflationary pressure is evident upon all the variables of the economy in question, estimation without deflating might not effect the variables so badly. Taking the variables separately rather than a ratio can enable to understand the separate influence of the individual variables. In model 3, fertilizer price may also be seen as a ratio or profitablity as we have deflated fertilizer price by output price index.

Non-price factors may effect the demand and it can shift the demand curve. Although adoption and diffusion of HYV technology depends upon many factors other than land but it is plausible that HYV acreage can serve as a proxy for the extent of its extension and act as a prime factor in determining fertilizer demand. The question may rise that given the production function where there are other factors of production, why have we not introduced them in the model. It is possible to include prices of other inputs of production other than fertilizer and output prices in the models, but these factors would not significantly effect fertilizer demand because in Bangladesh mechanization in agriculture is not so pervasive that we need to include the other production inputs. Since in this country, labor is abundant so it is likely that its price would not effect significantly the demand for fertilizer and finding an appropriate proxy for irrigation to incorporate in the model is difficult. But HYV cultivation requires irrigation so inclusion of HYV acreage may also serve as an irrigation proxy.

In case of estimating TSP models we have assigned the variable of sales of phosphate. This is because the sales of phosphate from other fertilizers increases, TSP sales would decrease. In Bangladesh initially phosphate sales was from Diammonium Phosphate (DAP) only and as time passed by, SSP replaced its place. However, in case of the explanatory variable in the model it is better to take the nutrient content, only the phosphate from DAP and SSP.

Estimation

In case of estimation we have taken the ordinary least square (OLS) approach. As we have assumed non linear production funciton, our derived function would be non linear, and so to estimate we have chosen the double log form of the function. We have assumed that our models possess the usual assumptions of OLS estimation. For constructing the models we have gone through usual econometric procedure and the violation of tests for OLS assumpitons are also taken into consideration.

Data

The estimated models used time series data from 1980-81 to 1995-96. Data up to 1993-94 was collected from different reports of the Fertilizer Distribution Improvement Project (FDI)-II. This project was implemented by International Fertilizer Development Center (IFDC) and these data was gathered by IFDC from primary and different secondary sources. After 1993-94, prices of fertilizer, average crop price and estimated sales of fertilizer were obtained from different reports of Agrobased Industries and Technology Development Project (ATDP), also being implemented by IFDC. The primary data collection procedure was monitored closely by the staff of IFDC and the field staff was well trained and qualified. The weighted average of fertilizer price and crop price are the data specially taken from the reports of IFDC and believed to be the reliable source of such data. In case of other variables, data were taken from the Bangladesh Bureau of Statistics (BBS) Statistical Year Book and the Ministry of Agriculture (MOA). Area under cultivation of HYV up to *1994-95* was taken from the Handbook of Agricultural Statistics of MOA and data of this variable for the period *1995-96* were taken from the perspective plan of Ministry of Agriculture, because actual estimate was not available. Harvest price index was constructed from the average output price where *1980-81* was the base year and the relative price of model 3 was calculated by (Fertilizer price/Harvest price index) x 100. In case of dummy variables, Aman and Boro seasons were assigned ' 1' and Aus was assigned '0'. Dummy variables were used to capture the seasonal variation of the demand, and for the purpose each year of the time series data of the period under consideration was divided into three seasons according to the general practice. The Aus season covers the period from April to June, Aman season from July to October and Boro season from November to March.

III. RESULTS OF THE ESTIMATED MODELS

The estimated models are presented in the following Tables. The models for three types of fertilizers : urea, TSP and MOP were estimated separately. The significance level upto 20 percent level of individual coefficients were reported to show how the variables behave, but using the coefficients that show significance more than 10 percent level rests with individual and also with the purpose of the use. In model 1, in case of MOP two models were estimated; model (1) includes area under HYV crop and in (2) this variable has been dropped. In model 2, two models were estimated, in case of TSP model (1) considers the same variables as other fertilizers include, but in (2) the lag price of output was dropped.

IV. ANALYSIS OF THE ESTIMATED MODELS

Econometric Analysis

The models were checked for multicollinearity and autocorrelation. The question of multicollinearity was dealt with bearing Kementa's warning in mind: "Muticollinearity is a question of degree not of kind. The meaningful distinction is not between the presence and the absence of multicollinearity but between its various degrees". Condition index was used to find the possilbility of multicollinearity. The extent of multicollinearity was lower for all the estimates of model 1 compared to model 2 and 3. The Durbin Watson 'd' statistics was taken

Table 1 : Fertilizer Demand Estimate by Using Model 1

Variables	Estimated Coefficients			
	Urea	TSP	MOP (1)	MOP (2)
Constant	3.524*** (0.448)	1.885# (1.166)	2.283*** (0.581)	1.613*** (0.116)
Ratio of Fertilizer Price to HYV Paddy Price	-0.1463^{ns} (0.2140)	-0.1259^{ns} (0.4663)	-0. 6380*** (0.1892)	-0. 6146*** (0.1890)
Area Under HYV Crop ('000' Acre)	0.1465** (0.0652)	0.2809* (0.1687)	-0.0998^{ns} (0.0849)	
Time Trend	0.0247*** (0.0025)	-0.0007^{ns} (0.0066)	0.0397*** (0.0032)	0.0390*** (0.0031)
Seasonal Dummy (Aman)	0.4707*** (0.0968)	0.4063** (0.2660)	0.5565*** (0.1264)	0.4414*** (0.0804)
Seasonal Dummy (Boro)	0.8813*** (0.1274)	1.1531*** (0.3602)	1.4152*** (0.1655)	1.2446*** (0.0802)
Sales of Phosphate		-0.2071*** (0.0552)		
Adjusted R^2	0.92	0.75	0.91	0.90
F- Value	104	16	84	104
DW	2.35	1.09	1.93	1.87
No. of Observations	45	32	45	45

Figures in parentheses represent standard error. Significance of the individual coefficients by t statistics are represented as *** *Significant at 1% level* ** *Significant at 5% level* * *Significant at 10% level # Significant at 20% level, and 'ns' non-significant.*

to find the possibility of autocorrelation in the models. There were no evidence of autocorrelation in the following models; Model 1: for urea and MOP, Model 2: MOP and Model 3: urea and MOP and 'd' statistics fell in the inconclusive region for TSP in Model 1, urea and TSP in Model 2 and for TSP in Model 3. The critical value of 'd' statistics was taken at 1% level of significance[4].

The statistical significance of the individual coefficients are presented in the Tables. The overall significance of the multiple regressions as indicated by the F-statistics says all the slope coefficients are not simultaneously zero. F-statistics for all the regressions were significant at 1% level. The adjusted R square for all the models were more than 90% except for TSP models. The explanatory power for the variables of TSP ranged between 75% to 79%.

One important point to note is that the observations for TSP were reduced during the estimation, which was due to the fact that, for some periods TSP was the only phosphate used for cultivation. So as other phosphates were absent, the value was '0' and as we used double log form of the models, the computer software package did not transform these '0' into log and treated those as missing values.

Table 2: Fertilizer Demand Estimate by Using Model 2

Variables	Estimated Coefficients			
	Urea	TSP		MOP
		(1)	(2)	
Constant	3.544*** (1.363)	10.818*** (4.677)	11.301*** (3.965)	5.060*** (1.553)
Price of Fertilizer (Tk/50 Kg)	-0.0999^{ns} (0.3237)	-1.8785** (0.7781)	-1.8712** (0.7616)	-1.0968*** (0.2403)
Lag Price of HYV Paddy	0.0965^{ns} (0.2257)	0.1044^{ns} (0.5070)		0.5218*** (0.2081)
Area Under HYV Crop ('000' Acres)	0.1456** (0.0672)	0.2326# (0.1579)	0.2346* (0.1545)	-0.1025# (0.0759)
Time Trend	0.0251*** (0.0037)	0.0449** (0.0223)	0.0465** (0.0204)	0.0537*** (0.0073)
Seasonal Dummy (Aman)	0.4709*** (0.0993)	0.5521** (0.2577)	0.5465** (0.2510)	0.5585*** (0.1132)
Seasonal Dummy (Boro)	0.8931*** (0.1314)	1.264** (0.3411)	1.2510*** (0.3307)	1.4865*** (0.1505)
Sales of Phosphate		-0.1546*** (0.0567)	-0.1560*** (0.0531)	
Adjusted R^2	0.92	0.79	0.79	0.92
F- Value	84	17	20	90
DW	2.42	0.98	0.97	2.04
No. of Observations	45	31	31	45

Figures in parentheses represent standard error. Significance of the individual coefficients by t statistics are represented as *** *Significant at 1% level* ** *Significant at 5% level* * *Significant at 10% level # Significant at 20% level, and 'ns' non-significant.*

Table 3: Fertilizer Demand Estimate by Using Model 3

Variables	Estimated Coefficients		
	Urea	TSP	MOP
Constant	4.755** (1.962)	3.075^{ns} (4.624)	8.333*** (1.804)
Relative Price of Fertilizer (Deflated by HPI)	-0.1292^{ns} (0.2014)	-0.1239^{ns} (0.4669)	-0.6318*** (0.1818)
Area Under HYV Crop ('000' Acres)	0.1472** (0.0643)	0.2809* (0.1687)	-0.0977^{ns} (0.0834)
Time Trend	0.0250*** (0.0023)	0.0007^{ns} (0.0066)	0.0398*** (0.0031)
Seasonal Dummy (Aman)	0.4667*** (0.0942)	0.4067^{ns} (0.2662)	0.5495*** (0.1224)
Seasonal Dummy (Boro)	0.8803*** (0.1257)	1.1534*** (0.3603)	1.4101*** (0.1629)
Sales of Phosphate		-0.2071*** (0.0552)	
F-Value	109	16	89
Adjusted R^2	92	75	91
D W	2.35	1.09	1.92
No. of Observations	45	31	45

Figures in parentheses represent standard error. Significance of the individual coefficients by t statistics are represented as *** *Significant at 1% level* ** *Significant at 5% level* * *Significant at 10% level # Significant at 20% level, and 'ns' non-significant.*

Choosing a model

i) In case of urea, model 1 appears to be a good model. Because multicollinearity was lower compared to other models and autocorrelation was absent. In model 1, although price ratio was not statistically significant for urea but it was not dropped and used as an explanatory variable due to theoretical importance. The price ratio for both the models (1) and (3) were not significant at coventional significance level but this variable showed relatively higher significant level (indicated by exact level of significance) in model 1 compared to model 3.

ii) In case of TSP, model 2 showed a better result after dropping the lag HYV paddy price. It is apparent from the three models that model 2 of TSP (2) can be used for projection or policy analysis. One point should be noted that for all the TSP models, it was not possible to comment precisely on the problem of autocorrelation as the 'd' statistics fell in the inconclusive region and also because 'd' statistics does not consider the missing values.

iii) Model 1 can be used for projection or policy analysis of the demand for MOP. For MOP in this Model, the coefficient of area under HYV cultivation was neither theoretically consistent nor was statistically significant. So the variable was dropped and MOP (2) was estimated and can be considered as a good model. Multicollinearity was low and autocorrelation was absent. Model (2) can be used with caution because the variables were not taken in real terms and model (3) was not a good one because model (1) shows a better explanatory power of the variables indicated by adjusted R square and multicollinearity was higher in model 3.

Regarding the problem of multicollinearity, which exists in the estimated models, we could have taken some "ad hoc" measures to control multicollinearity by dropping some variables but this would lead us to the problem of specification error. In the section choosing a model we have considered the models with the lowest multicollinearity. However, if the purpose of estimation is only to forecast the values of dependent variable, the problem of multicollinearity can be ignored assuming that the explanatory variables will move in the same direction in future.

Behavior of the Variables

In the estimation it can be seen that the price ratio or price of fertilizer for all the fertilizer shows a proper theoretical sign indicating an inverse relationship with the fertilizer sales. It appears that the price of urea does not act as a significant determinant of its demands. This can be supported by the fact that, in the fertilizer crisis period of 1995 and 1996, the total sales of urea was not significantly different from the previous year, in the same season, indicating price of fertilizer is not the significant factor underlying demand.

If this is the case then it should be true that even with higher prices of urea, other than the normal market price the adoption of HYV is still profitable. However, it is also possible that, once the farmers decide to use their land for HYV cultivation they cannot refrain even the price of one of the inputs becomes high, because this would mean a total loss for the season or impossibility of the farmers to meet bare necessities of their families. In case of TSP and MOP, the prices appear to have a significant effect in their demand and their demand are price elastic. In recent days price of TSP has increased substantially which is due to low domestic production and increased transportation cost of imported TSP in the market. Consequently farmers are moving towards the use of SSP. The relative importance of price in TSP and MOP demand compared to urea may be attributed to the farmers obsession towards the use of urea and relatively less inclination towards TSP and MOP.

In all the cases, the non price factors played important role in the demand function. Over time use of fertilizer has increased and farmers knowledge on HYV technology has taken a stable form. In addition, other factors are partially explaining the consumption of fertilizer, these are indicated by the coefficient of the time variable. Area under cultivation played a vital role in determining demand for fertilizers like urea and TSP but it does not influence significantly the demand for MOP. The reason may be that cultivated area itself does not play any role directly but via other variables. It may also be due to its dependence upon the use of other types of fertilizers and the MOP demand is not tied to the HYV area.

Sales of other types of phosphate is inversely related to the consumption of TSP supporting our hypothesis. Since 1989-90 other type of phosphate in use is SSP only and its consumption increased drastically, from 12 thousand MT during 1990-91 to 533 thousand in 1994-95. Reason for the negative relationship is obvious, the farmers are willing to get the nutrient, and as they purchase one type of phosphate, purchase of the other types decline.

The seasonal variation in fertilizer consumption is evident here as indicated by the dummy variables. Fertilizer consumption is higher in Boro season compared to Aman and Aus. This seasonal variation is an important factor in the demand function and should be considered in determing production and distribution of fertilizer. Consumption of fertilizer increases in Aman and Boro seasons primarily because of the higher acreage compared to the Aus season.

The question of inclusion of income as a proxy can be taken into consideration. Some researchers believe that there is no good theoretical reason for income in the demand equation because it is at least not derived from the traditional theory of the farm. But others say that farm income should be included if the farmer is to maximize profit under constraint, where income is the constraint (see Timmer, 1974). We have introduced income in our model but the result is not encouraging. The lag price of output in the model 2 was not statistically significant for urea and TSP but siginificant for MOP. David (1976) used value of output as a proxy for financing ability of the farmers as a determinant of fertilizer demand in some Asian countries. In one area he found the estimated coefficient to be statistically insignificant and did not contribute much to R^2 and concluded "-either financing of fertilizer purchase is not a constraint to farmers' effective demand or value of output is not an appropriate proxy variable for farmers' liquidity position". In our case it is possible that the average output price does not play a significant role as financial constraint in farmers' fertilizer demand.

Limitations

Time variable has been considered in the models as "the catch all variable" and the "technological change" was seen as included in the variable but the expenditure on agriculture extension would give a better picture. It is also possible to include seasonal rainfall as an explanatory variable. These two variables were not included due to unavailability of data. Non traditional use of fertilizer has increased substantially in these days. Examples are use in fish farming, livestock, rice husking, printing and dying. But this variable was not introduced explicitly due to absence of time series data. Prices of other nutrients were not included as explanatory variables on the assumption that they might not act as a significant factor, but this non-complementarity assumption may be considered as a limitation.

The use of Durbin Watson statistic (d) in case of TSP was inappropriate because it does not consider the missing values. On theoretical ground, use of Cobb-Douglus production function and underlying assumptions in the profit functions might be questioned.

V. CONCLUDING REMARKS

In this study attempt has been made to estimate fertilizer demand function by type and estimation was done for Urea, TSP and MOP. SSP use has increased but it was not possible to estimate demand for SSP economertically due to small number of observations and few missing observations.

Future research may be performed considering other forms of production functions and also try to eliminate the limitations mentioned above. In these days SSP consumption is substantial. It would be an interesting idea to look into the factors affecting its demand, if appropriate data are available.

In the three estimated models it is interesting to note that the price variable in case of urea was statistically insignificant indicating that it does not act significantly as an explanatory variable. This can be supported by empirical evidence that during the fertilizer crisis in 1995 or 1996 sales of urea was not reduced despite substantial rise in price.

From this analysis it is possible to make projections of demand for future periods. If we consider this estimates to be valid, it is possible to show that the domestic supply of urea will not be able to meet demand in near future considering the production capacity of the domestic urea factories. In addition TSP and MOP availability should be raised to a certain level to keep pace with demand. It is likely that urea has to be imported if demand becomes higher compared to supply in near future and the production capacity of the factories are not increased. But the domestic price of the imported urea would be much higher compared to the existing retail price considering the current international pirce of urea. This is the time to take decision, if we are to import urea and increase retail price without subsidizing it or if we are to increase the capacity of the domestic factories and raise urea availability.

Footnotes :

1. Considering production function as

$$Y = AF^{\alpha}L^{\beta} \tag{1}$$

Where Y is output and F is fertilizer and L is another factor of production and we have the profit function Π

$$\Pi = PY-P_1F-P_2L=P(AF^{\alpha}L^{\beta})-P_1F-P_2L$$

Where P=price of output, P_i=factor price, i=1, 2

Considering necessary condition for profit maximization

$\delta\Pi/\delta F = \alpha PAF^{\alpha-1}L^{b''}\text{-}P_1=0$

or $\alpha PAF^{\alpha}L^{\beta}/F=P_1$

or $\alpha PY/F=P_1$ or $Y/F=P_1/\alpha P$ (2)

$\delta\Pi/\delta F = \beta PAF^{\alpha}L^{\beta-1} - P_2=0$

or $\beta\ PY/L = P_2$ or $Y/L = P_2/\beta P$ (3)

From equation (1)

$\log Y = \log A + \alpha \log F + \beta \log L$ (4)

From equation (2)

$\log Y\text{-}\log F = \log (P_1/\alpha P)$

or $\log Y = \log F\text{+}\log (P_1/\alpha P)$ (5)

From equation (3)

$\log Y\text{-}\log L = \log (P_2/\beta P)$

or $\log L = \log Y\text{+}\log (P_2/\beta P)$ (6)

Combining equation (4) & (5)

$\log F\text{+} \log (P_1/\alpha P) = \log A\text{+} \alpha \log F\text{+}\beta \log L$

$\log F\text{-}\alpha \log F = \log A + \beta \log L\text{-}\log P_1/\alpha P$

$\log F\text{-}\alpha \log F = \log A + \beta (\log Y\text{-}\log P_2/\beta P)\text{-}\log P_1/\alpha P$ (from 6)

$\log F\text{-}\alpha \log F = \log A + \beta (\log F + \log P_1/\alpha P\text{-}\log P_2/BP)\text{-}\log P_1/\alpha P$

$\log F\text{-}\alpha \log F = \log A + \beta \log F + \beta \log (P_1/\alpha P)\text{-}\log P_2/P\text{-}\log P_1/\alpha P$

$\log F\text{-}\alpha \log F\text{-}\beta \log F = \log A + \beta \log P_1/\alpha P\text{-}\log P_2/P\text{-}\log P_1/\alpha P$

$\log F(1\text{-}\alpha\text{-}\beta) = \log A + \log P_1/\alpha P\ (\beta\text{-}1) \log P_2/P$

$\log F = (\log A\text{+}\log P_1/\alpha P\ (\beta\text{-}1)\text{-} \log P_2/P]/(1\text{-}\alpha\text{-}\beta)$

$\Rightarrow F=f(P_1/P, P_2/P)$

This can be generalized for number of variables. Question may be raised that why then we have used price of output and fertilizer separately in model 2. By following this approach it is also possible to show that demand of fertilizer is a function of output price and fertilizer price as two separate arguments. So, it is possible to take input output price ratio or simply these prices separately as explanatory variables.

2. This idea has been taken from Parikh, A. K. (1965)

3. We can have a plausible explanation of the factor price output price ratio. Let us assume price per unit of fertilizer is Tk. 10 and price of output per unit is Tk. 20, the ratio is 0.5—this indicates one unit of output can purchase two units of fertilizer. Now let us assume price of fertilizer becomes Tk. per unit but output price remains the same so the ratio becomes 0.25 indicating that by one unit of output four units of fertilizer can be purchased—therefore fertilizer sales would increase. And this analysis is in real terms. This is the rational to include the ratio as one of theexplanatory variable.

4. The critical value of D. W. at 1% level are $d_L = 1.065$ and $d_u = 1.643$ for 45 observations and 6 explanatory variables, $d_L = 1.111$ and $d_u = 1.584$ for 45 observations and 5 explanatory variables, $d_L = 0.794$ and $d_u = 1.788$ for 32 observations and 7 explanatory variables, $d_L = 0.834$ and $d_u = 1.698$ for 31 observations and 6 explanatory variables.

5. A study of nitrogenous fertilizer in India for the period between 1951-61 found this sign to be positive in some Indian states which the study says may be due to two reasons. One is that, price do not have any systematic effect on demand due to its stable trend or it is constant, and another reason can be, in the case of uncertainty in fertilizer use for the period tested, new and better equilibrium may be attained through time and not by adjusting to price (Parikh, 1965).

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